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NOTES ON LOW TEMPERATURE VULCANIZATION

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CONSIDERABLE interest has been taken recently by Rubber Producers in Ceylon and no doubt in other countries, in the possibilities of producing certain types of vulcanized products direct from latex on the plantations. Interest has partly been stimulated by the low selling price of raw rubber but also by the knowledge that the direct utilisation of latex has made substantial progress in manufacturing countries and that methods of vulcanization have been considerably simplified in recent years.

Until comparatively few years ago vulcanization was effected by heating a mixture of rubber and sulphur for several hours at a temperature of about 300°F but a class of substances known as accelerators has been developed which, when added to the mixing in small proportion, enables the process to be carried out at a lower temperature or alternatively in a shorter time. The more powerful accelerators are usually known as ultra-accelerators. Some of them are claimed to effect vulcanization at ordinary temperature but this form of "self-vulcanization" does not appear to be relied on to any great extent in countries with a temperate climate.

A number of enquiries have been received by the Research Scheme regarding suitable methods of low temperature vulcanization and it is considered to be of interest to give an outline of some trials which have been made by the writer on the preparation of vulcanized crepe rubber by the addition of suitable ingredients to the latex before coagulation. The purpose of the trials was mainly to determine whether a substantial degree of vulcanization can be effected without heating the rubber.

The accelerator used in most of the experiments was Zinc diethyldithiocarbamate (usually abbreviated to Z.D.C.), one of the well-known ultra-accelerators which is marketed in the form

of a fine white powder, insoluble in water. The sodium salt of the same substance (S.D.C.) which is soluble in water, has also been used and gives similar results. The accelerator together with zinc oxide and sulphur was mixed into a cream with water containing a wetting agent and added to the latex, which was then coagulated and creped in the ordinary way. After being air dried the crepe was made up into laminated sheets on the lines of the Ceylon method of sole crepe manufacture.

The method used for judging the extent of vulcanization was to observe the effect of benzene on the rubber. Raw rubber dissolves in benzene and other hydrocarbon solvents whereas vulcanized rubber swells without dissolving. The extent of swelling depends on the stage of vulcanization and decreases as vulcanization proceeds. Accurate methods for measuring the extent of swelling of rubber in solvents have been described by Scott [1] and van Wijk [2] but only approximate results were required in the present trials and the amount of swelling was calculated from the dimensions of the test pieces before and after 24 hours' immersion in benzene.

It was found from a series of experiments that crepe rubber prepared from compounded latex under suitable conditions cures slowly at ordinary temperature (75°F-90°F) and is sufficiently vulcanized after about 20 days to be resistant to sunlight and heat and insoluble in raw rubber solvents. The rate of vulcanization varies considerably according to the conditions of preparation as is shown by the following examples:

1. EFFECT OF COAGULANT ON RATE OF VULCANIZATION

(Mixing containing zinc oxide 3 parts, sulphur 1·5 parts, Z.D.C. accelerator 0·75 parts per 100 parts rubber).

Coagulant	Percentage increase in volume of sample when immersed in benzene for 24 hours at different intervals after preparation			
	10 days	20 days	30 days	40 days
a. Formic acid 1:100	dissolved	dissolved	dissolved	almost sticky
b. Alum 1:30	dissolved	940% (sticky)	760%	740%

The test shows that alum is a more suitable coagulant than formic acid for this type of mixing.

2. EFFECT OF SODIUM BISULPHITE ON RATE OF VULCANIZATION

(Mixing containing zinc oxide 3 parts, sulphur 1·5 parts, Z.D.C. accelerator 0·75 parts per 100 parts rubber).

Coagulant	Percentage increase in volume of sample when immersed in benzene for 24 hours at different intervals after preparation			
	10 days	20 days	30 days	40 days
a. Alum 1 :30 without sodium bisulphite	dissolved	940% (sticky)	760%	740%
b. Alum 1 :30 + sodium bisulphite 1 :200	sticky	720%	540%	540%

The test shows that vulcanization is assisted by the presence of sodium bisulphite in the latex. The colour of the product is also improved.

Among minor factors which influence the rate of vulcanization it was found that (a) colloidal zinc oxide gives slightly better results than the ordinary commercial product (b) certain dyestuffs used for colouring the latex have a slight retarding effect (c) wetting agents vary in their effect on vulcanization.

As a result of the trials a satisfactory method was worked out for the preparation of self vulcanizing crepe rubber and an outline is given below:

LATEX

Fresh latex is diluted to a dry rubber content of 3 lb. per gallon and treated with 1 part of sodium bisulphite to 200 parts rubber, added in the form of 5 per cent solution.

VULCANIZING INGREDIENTS

	Quantities per 100 lb. dry rubber	Cost of ingredient per lb	Cost per 100 lb. rubber
		Rs. cts	Rs. cts.
Zinc Oxide	3 lb.	22	66
Sulphur (special grade for latex mixings)	$1\frac{1}{2}$ lb.	08	12
Z.D.C. or S.D.C. accelerator	$\frac{3}{4}$ lb.	6·90	5·17
Colouring matter if required (Vulcafor)	$\frac{1}{2}$ lb.	5·00*	2·50

* colours vary in price.

WETTING INGREDIENT

Vulcastab A paste	$\frac{1}{4}$ lb.	1·00	25
or saponin	$1\frac{1}{4}$ oz.	(5·00)	(39)

(Dissolved in $1\frac{1}{2}$ gallons water).

COAGULANT

Alum	$3\frac{1}{4}$ lb.	35	1·14

(Dissolved in $3\frac{1}{4}$ gallons water).

Total ... Rs. 9·84

The amount of zinc oxide depends on the type of product and may be increased to 10-20 per cent. if white crepe is required or to give a softer tone to coloured rubber. The cost of the mixing can be further reduced by adding up to 33 per cent. of china clay. Other cheap fillers such as whiting have not been tried but would probably be satisfactory.

The chemicals referred to (except saponin) can be obtained locally from Messrs. Imperial Chemical Industries Ltd.

MIXING THE INGREDIENTS

Before adding the vulcanizing ingredients to the latex they must be ground up thoroughly into a cream with the solution of wetting agent. On a small experimental scale, such as when dealing with the quantities required for 1-2 gallons of latex, this can be done satisfactorily by grinding in a mortar but on a larger scale the operation is carried out in a ball grinding mill. Thorough mixing is essential to ensure uniform distribution of the ingredients in the latex.

COAGULATION, MACHINING, ETC.

The vulcanizing mixture is slowly added to the latex and vigorously stirred to ensure thorough mixing and to prevent the powders settling. The alum solution is then added and stirring continued until the mixture thickens, which occurs within a few minutes. After an hour the mixture will be in the form of a thick paste but forms a coherent coagulum when stirred.

It is preferable to machine the coagulum within a few hours, but it can be left overnight if required. The rubber is made into lace crepe in the ordinary way and hung to airdry. Drying is more rapid than with raw rubber and is usually completed within 3-4 days. Dry rolling should not be done until 12-14 days after preparation and the rubber may then be made up into laminated sheets by the usual Ceylon sole crepe method.

THE PRODUCT

The material prepared by this method is similar in texture to Ceylon type sole crepe but is sufficiently vulcanized to be resistant to heat and sunlight and it absorbs water less readily than raw rubber. There is no commercial demand for the product at present but it appears to be a suitable material for

use as table mats, bath mats etc. A similar product was made in Malaya a few years ago as a material for shoe soles but did not meet with great success owing to the increased cost of manufacture and the difficulty of disposal of trimmings.

It is not the purpose of these notes to suggest that there is any substantial outlet for this particular material but rather to give an indication of the type of ingredients which are employed in latex compounding and the method of using them. It should be emphasised that accurate control of quantities and careful mixing of ingredients are essentials if satisfactory results are to be obtained. The proportions of sulphur and accelerator used in latex mixings should not usually exceed 2 per cent. and 1 per cent. respectively and the presence of a small quantity of zinc oxide is necessary to activate the accelerator, but the proportion of this and other fillers may be varied according to the type of product required.

REFERENCES

(1) J. R. Scott.—*I.R.I. Trans*: Vol. V, 1929 p. 95.

(2) D. J. van Wijk.—*Kautschuk* Vol. IX, 1933, p. 18.

REPORT ON SOFTENED RUBBER

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CREPE and sheet are not sufficiently plastic for most purposes, and are therefore almost invariably masticated by manufacturers. Mastication consists in passing the rubber through heavy rolls for about 15 minutes. This reduces it to a soft, plastic condition so that compounding ingredients can be incorporated and the mixture afterwards formed to the shape required. If rubber could be prepared on the plantations in a sufficiently plastic condition, mastication would be unnecessary. It is difficult to obtain a figure for the average cost of mastication, but information received from some manufacturers indicates that it is unlikely that the cost exceeds ½d. per lb. of rubber. This economy is not in itself a strong incentive for the preparation of very soft plantation rubber, but soft rubber has other and more important advantages which would ensure a demand for a suitable material. These advantages are connected with (1) the incorporation of large quantities of compounding ingredients, (2) a reduced tendency to scorch in mixings containing ultra-accelerators of vulcanisation, (3) an increased output from various machines used for shaping rubber, (4) a reduced tendency to recover in shape, and (5) the preparation of rubber solutions of low viscosity. The value of these advantages depends upon circumstances. Established factories with a wealth of experience in the use of crepe and sheet probably have the least need for very soft rubber. On the other hand it would be of considerable benefit to factories already working at full capacity, to new factories; and to factories which have experienced difficulty in the incorporation of some accelerators or of large quantitites of compounding ingredients for special purposes. The advantages are of sufficient importance to indicate that soft rubber with good vulcanising and ageing properties would meet with a steady and probably increasing

demand if the price is similar to that of crepe and sheet. If a premium is necessary, the demand will obviously decrease in proportion to the amount of the premium. Part of the demand for very soft rubber would be at the expense of crepe and sheet and lower grade rubber, and part would be due to the use of rubber for purposes where it is now only employed with difficulty.

Since the early days of the rubber industry it has been possible to soften crepe and sheet by mastication without markedly affecting the quality of the vulcanized rubber, but it has not been possible to obtain a very soft product without seriously affecting the vulcanising and ageing properties. A process has now been devised by Ungar and Schidrowitz (E.P. 368,902) which they claim produces a very soft material with little deterioration of vulcanising and ageing properties. The process consists in washing crepe and sheet in a Werner-Pfleiderer washer until it is in the form of a crumb, which is dried in vacuo for 2 hours at 170 to 175°C. Air is then admitted and the heating continued for about ¾ hour, after which the rubber is allowed to cool slowly and then passed through rolls to form uniform slabs. The essential feature of the process appears to be oxidation of dry rubber at 170-175°C followed by oxidation during cooling.

It has already been shewn by Cotton (2me Congrès Intern. des Technic. du Caoutchouc, Paris 1931) that rubber cannot be plasticised by mastication in the absence of oxygen, from which it appears that softening produced during mastication is induced by oxygen. The process of Ungar and Schidrowitz is therefore theoretically related to mastication, although of course the softening induced by oxygen at a high temperature may be different from that induced by oxygen during rolling at ordinary temperatures.

In view of the general interest of manufacturers in "softened" rubber prepared according to this process and its importance to the rubber grower, two samples were obtained for examination in the London Laboratories of the London Advisory Committee for Rubber Research (Ceylon and Malaya).

The first sample consisted of dark-coloured shreds of rubber matted together. It was somewhat sticky, and had been dusted with a surface lubricant. The second sample which was in the form of a slab was more uniform than the first sample, and resembled in appearance some types of reclaim. Both samples were obviously much softer than crepe or sheet.

The samples were submitted to manipulative, vulcanising and ageing tests.

PLASTICITY

The hardness of the two samples is represented by a D_{80} value of 0·56 mm. and 0·54 mm. respectively as compared with 1·00 mm. for masticated and 1·70 mm. for unmasticated rubber. The softened rubber is therefore much softer than masticated rubber. When passed through rolls ten times in order to bring it into a condition suitable for testing, the plasticity of the softened rubber was found to be 20 times as much as that of crepe or sheet passed through rolls 100 times, which is the average amount of rolling required to masticate crepe or sheet. "Softened" rubber is therefore a much more plastic material than can be obtained by ordinary mastication.

After passing through rolls 50 times a mixture of equal parts of softened rubber and smoked sheet was 14 times as plastic as smoked sheet alone passed through 100 times. Softened rubber can therefore be employed as a softener for estate grades of rubber.

When the softened rubber was mixed without preliminary mastication with 27 per cent. zinc oxide, it still had a plasticity which was roughly 20 times that of the corresponding mixing made from crepe or sheet. The mixture extruded very rapidly and smoothly, and only recovered to the extent of 24 per cent. as compared with double the amount for the corresponding mixing made from crepe or sheet. In this respect softened rubber compares favourably with reclaim which also exerts a beneficial influence on the recovery of rubber mixings.

These experiments show that softened rubber has marked advantages over crepe or sheet as regards manipulation.

VULCANISATION AND AGEING

The following are the results of vulcanisation tests in a rubber-sulphur mixing (100:10) at 148°C.

Sample No.	Time of vulcanisation at 148°C.	Tensile Strength	Elongation at load of 0·6 kgs./sq. mm.
	(mins.)	(lb./sq. in)	(per cent.)
2.	120	780	891
	140	1,100	824
	160	1,630	768
	180	1,520	698

The sample vulcanised about 40 per cent. slower than average Ceylon smoked sheet, and the maximum tensile strength was about 30 per cent. less than that of average crepe or sheet.

The following are the results of vulcanisation and artificial ageing tests on both samples in a rubber-sulphur mixing (90:10) at 148°C.

Sample No.	Time of vulcanisation	Ageing Period at 70°C.	Tensile Strength	Elongation at load of 0·6 kgs./sq.mm.
	(mins.)	(hours)	(lb./sq. in)	(per cent.)
1.	117	nil	1,130	775
		48	1,200	672
		96	280	—
2.	141	nil	1,250	780
		48	1,660	668
		96	360	—

The first sample vulcanised about 20 per cent. slower than Ceylon sheet, and the second sample 40 per cent. slower. Both samples were about 30 per cent. weaker than crepe or sheet soon after vulcanisation, and perished in less than 96 hours without any preliminary marked increase in strength. Crepe and sheet are almost invariably strong after ageing for 96 hours, and sometimes are still strong after ageing for 144 hours.

These results indicate that the samples are definitely inferior to crepe and sheet in pure rubber-sulphur mixings.

In view of these results the sample No. 1 was vulcanised in an accelerator mixing consisting of 100 rubber, 6 zinc oxide, 3·5 sulphur, 0·5 captax in comparison with crepe. The following results were obtained:—

		Softened Rubber		*Masticated Crepe*	
Sample No.	Time of vulcanisation at 126°C.	Tensile Strength	Elongation at load of 0·6 kgs./sq. mm.	Tensile Strength	Elongation at load of 0·6 kgs./sq. mm.
	(mins.)	(lb./sq. in.)	(per cent.)	(lb./sq. in.)	(per cent.)
1.	20	580	—	1,530	896
	40	1,040	736	1,920	774
	60	1,110	728	2,060	761
	80	—	—	2,000	742
	90	1,180	691	—	—

In this mixing the "softened" rubber had a higher modulus than crepe but its strength was only a little more than half that of crepe.

The results obtained in this mixing are affected by the amount of fatty acids naturally occurring in the rubber. The second sample of "softened" rubber had an acetone extract of 2·72 per cent., and an acid value of 176. The acid value of the sample was somewhat lower than that of crepe or sheet.

A vulcanisation and ageing test was therefore carried out with the second sample of softened rubber in the same accelerator mixing, but containing in addition 1 part of stearic acid for 100 parts of rubber. The softened rubber required 45 minutes' vulcanisation as compared with 55 minutes for crepe so as to give approximately the same elongation under fixed load. The following are the results of the ageing tests:—

	Softened Rubber				*Crepe*			
Sample No.	Time of vulcanisation at 126°C	Period of ageing at 82½°C	Tensile Strength	Elongation at load of 1·04 kgs./sq. mm.	Time of vulcanisation at 126°C	Period of ageing at 82½°C	Tensile Strength	Elongation at load of 1·04 kgs./sq. mm.
	(mins.)	(days)	(lb./sq.in)	(per cent.)	(mins.)	(days)	(lb./sq.in)	(per cent.)
2.	45	nil	2,030	771	55	nil	2,230	794
		3	2,250	636		3	2,550	675
		6	1,530	560		6	2,180	606
		8	1,080	—		8	1,750	589

In this mixing containing stearic acid the "softened" rubber was only about 10 per cent. weaker than crepe, but the difference is increased by artificial ageing. An experiment was therefore carried out in which an anti-oxidant was added to the mixing, the anti-oxidant being 0·5 per cent. antox for 100 parts of rubber. The following results were obtained:—

	Softened Rubber				*Crepe*			
Sample No.	Time of vulcanisation at 126°C	Period of ageing at 82½°C	Tensile Strength	Elongation at load of 1·04 kgs./sq. mm.	Time of vulcanisation at 126°C	Period of ageing at 82½°C	Tensile Strength	Elongation at load of 1·04 kgs./sq. mm.
	(mins.)	(days)	(lb./sq.in)	(per cent.)	(mins.)	(days)	(lb./sq.in)	(per cent.)
2.	18	nil	1,730	761	30	nil	2,790	753
		2	2,750	556		2	2,940	589
		4	2,530	518		4	2,450	561
		6	2,450	490		6	1,980	543
		8	2,000	494		8	2,330	551
		10	460	—		10	250	—

The anti-oxidant had a marked accelerating effect upon the vulcanisation of both crepe and "softened" rubber. Apart from the initial tensile strength prior to ageing, the softened rubber compares very favourably with crepe.

These experiments indicate that in the combined presence of stearic acid, accelerator and antioxidant "softened" rubber may give results on vulcanisation and ageing comparable with standard crepe, but in the absence of these ingredients the results are not so satisfactory.

As the chief outlet for softened rubber would probably be in mixings containing considerable quantities of compounding ingredients, a final experiment was carried out in comparison with smoked sheet in an accelerator mixing containing equal parts by weight of rubber and zinc oxide, the compounding ingredients in the case of the softened rubber being mixed into the rubber on warm rolls without preliminary mastication. The mixing consisted of 100 parts rubber, 100 zinc oxide, 5 sulphur 1 D.P.G. The following results were obtained:—

	Softened Rubber			*Smoked Sheet*	
Sample No.	Time of vulcanisation at 141°C.	Tensile Strength	Elongation at load of 0·6 kgs./sq. mm.	Tensile Strength	Elongation at load of 0·6 kgs./sq. mm.
	(mins.)	(lb./sq. in.)	(per cent.)	(lb./sq. in.)	(per cent.)
2.	10	1,630	508	1,750	482
	20	2,060	443	2,730	396
	30	2,670	414	3,170	354
	40	2,710	397	3,590	308
	60	2,430	370	3,150	290

The tensile strengths of the "softened" rubber in this mixing are somewhat lower than that of the smoked sheet mixing, the extent of the difference being similar to that occurring in a rubber-sulphur mixing. The experiments indicate that a mineral compounding ingredient such as zinc oxide does not exert a marked effect on the relative strengths of vulcanised softened rubber and smoked sheet mixings prior to ageing.

Subsequent to these investigations a third sample of softened rubber was received from Dr. Schidrowitz obtained by the oxidation of crumb rubber prepared from preserved latex according

to the process devised by the staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya). The rubber was in the form of a sheet and on arrival was in a frozen condition. On thawing the sample was obviously soft but was only slightly "tacky". Its hardness (D_{30}) at 100°C was 0·30 mms., which is less than that of samples of "softened" rubber previously examined.

It required no mastication. The rate of absorption of compounding ingredients appeared to be a little quicker than for normal masticated rubber. In mixings containing small quantities of compounding ingredients the rubber did not calender well and contracted rapidly on cooling. In heavily loaded mixings such as those containing equal parts of rubber and zinc oxide the rubber could be calendered with ease without marked contrac tion being observed.

The sample was vulcanised in the following mixing, which previous work at the Imperial Institute has shown gives good results with softened rubber:—

Rubber	...	100
Zinc Oxide	...	6
Sulphur	...	3·5
Captax	...	0·5
Antox	...	0·5
Stearic acid	...	1

For comparison tests were also made with the above mixings containing smoked sheet instead of "softened" rubber and with the mixing containing equal parts of "softened" rubber and smoked sheet.

The following are the results obtained:—

	Smoked Sheet		*Smoked Sheet and Softened Rubber*		*Softened Rubber*	
Period of vulcanisation at 126°C.	Tensile Strength	Elongation at load of 1·04 kgs. /sq. mm.	Tensile Strength	Elongation at load of 1·04 kgs. /sq. mm.	Tensile Strength	Elongation at load of 1·04 kgs. /sq. mm.
mins.	lb./sq. in.	per cent.	lb./sq. in.	per cent.	lb./sq. in.	per cent.
20	2,030	840	2,230	737	2,460	687
40	2,490	716	3,040	633	2,640	589
50	2,940	712	2,840	623	2,670	589
60	2,910	684	2,830	593	2,510	559
80	2,890	670	3,110	584	2,300	552
100	2,680	665	2,670	587	2,260	555

The softened rubber is not as strong as smoked sheet in this mixing in spite of a higher modulus. The mixture of smoked sheet and softened rubber is however at least as strong as smoked sheet alone.

CONCLUSIONS

(1) Softened rubber has marked advantages over crepe and sheet as regards ease of manipulation. It does not require mastication, it extrudes more quickly and smoothly and recovers less from deformation. The advantages of softened rubber as regards manipulation are more marked in highly loaded mixings than in those containing small quantities of compounding ingredients.

(2) It vulcanises more slowly than crepe or sheet in rubber-sulphur mixings but has a distinctly higher modulus than crepe or sheet in the accelerator mixings tried.

(3) It has poor tensile strengths and ages badly in rubber-sulphur mixings. Large quantities of zinc oxide do not improve the strength of vulcanised softened rubber relative to similar mixings of crepe and sheet, but in the presence of zinc oxide, accelerator, stearic acid and antioxidant excellent results may be obtained on ageing.

(4) Mixtures of equal parts of crepe or sheet and softened rubber have slightly better mechanical properties than crepe or sheet alone when vulcanised in the accelerator mixings tried. This may be due to the effect of softened rubber on the modulus and also the reduced mastication required.

REMARKS

It is considered that softened rubber has important advantages as regards ease af manipulation. In some circumstances it gave excellent results in vulcanisation and artificial ageing tests, but the results were not quite as good as those given by crepe and sheet.

Particularly good results were obtained on vulcanising a mixture of equal quantities of softened rubber and smoked sheet and if the price is satisfactory* softened rubber may find a market for admixture with crepe and sheet to facilitate the production of a wide range of high class articles, or it may be used without crepe and sheet where ease of manipulation is of primary importance.

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* It is understood that the cost of manufacture is not more than ⅛d. per lb.

THE PREPARATION OF SOFT RUBBER BY MEANS OF SODIUM NITRITE

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SEVERAL factors have contributed during recent years to focus attention on the manipulative properties of rubber and to illustrate the importance of producing rubber which is easily and economically converted into vulcanised articles. For instance the demand for reclaim at a higher price than raw rubber is frequently stated to be due to its effect on the manipulative properties of rubber. Comparatively expensive synthetic resins have replaced rubber for some purposes partly because they are easier to manipulate. The interest displayed by rubber manufacturers in latex was originally due to the difficulty of converting crepe and sheet into suitably shaped vulcanised products. The demand for lower grade rubbers is partly due to the fact that they are softer and more easily manipulated than first grade crepe and sheet, and during the last twelve months a very soft product prepared by oxidising crepe and sheet has been marketed at a premium.

A novel method of preparing soft rubber has been devised recently by the Staff at the Imperial Institute working on behalf of the Ceylon Rubber Research Scheme, and developed by the Director of the Scheme in Ceylon. This method consists in adding to latex a small quantity of sodium nitrite dissolved in water and then coagulating the latex and crepeing the coagulum.

Sodium nitrite has no obvious effect upon rubber, but when treated with acetic or formic acid it yields nitrous acid which reacts with rubber to form a rubber nitrosite which is an amorphous yellow powder, but under the conditions chosen only a trace of nitrous acid combines with the rubber so that the product obtained is essentially rubber although it is much softer than crepe and sheet.

In an experiment carried out in Ceylon, latex was diluted to 20 per cent. dry rubber content. To this was added sufficient sodium nitrite in the form of a 10 per cent. solution to give 1 part of sodium nitrite per 30 parts of rubber. The latex was then coagulated with 10 per cent. acetic acid, the amount of acetic acid solution added being the same as the amount of sodium nitrite solution. A soft spongy coagulum was formed which was rolled the next day four times in grooved crepeing rolls geared 17:32. During each rolling the blanket became crumbly and tended to spread over the sides of the machine. The blanket was rolled to crepe in the smooth machine giving a thin weak plastic crepe which was hung to dry.

On arrival in London the dry rubber was as soft as well masticated rubber.

This report is not intended to be a critical review of this method of preparing soft rubber, but merely a statement of the method of preparation. The product obtained is a rubber with properties somewhat different from those of masticated crepe and sheet. It is not likely therefore to find a use for the same purposes as crepe and sheet.

METHODS OF PREPARING RAW RUBBER IN CRUMB OR POWDER FORM

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THE preparation of rubber in crepe, sheet or block form is familiar to everyone in the rubber industry, but the fact that it can also be prepared in crumb and powder form by a number of methods is not so well known.

It was shown by W. C. Davey (J.S.C.I., *44*, 1925, p. 515T) that when latex is sprayed in hot air with protective colloids such as glue, casein, saponin, etc. the dry rubber is obtained in the form of a fine powder. The amount of protective colloid required is extremely large (casein 15 per cent. glue 10 per cent. and saponin 5 per cent. of the dry rubber) and the product tends to cohere on keeping unless carefully sealed in a tin.

More recently a spray process for the preparation of rubber powder has been devised by Stam (Dutch Patent 55,223, 1932) using dextrine to prevent the amalgamation of the dry rubber particles. This method has the disadvantage that large quantities of dextrine are required (about 20 per cent. on the dry rubber) but the product obtained is extremely fine and can be packed in drums and tins for reasonable periods without the particles cohering.

A different type of spray process has been devised by de Schlepper (B.P. 392,592) in which the latex is sprayed in hot air on to a moving band from which it is removed in the form of a crumb by scraping. This process has the advantage that it avoids the use of large quantities of protective colloids but the product is not so fine; whereas the other spray processes yield a very fine powder, this process yields a crumb.

A different method of preparing raw rubber crumb has been devised at the Imperial Institute by the Staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya). This process consists in the mechanical disintegration of wet

coagulum, which is then dried in air. The method of disintegration employed consists in passing the coagulum through rolls so as to obtain a considerable amount of "slip" between the coagulum and the rolls. The "slip" can be increased by the use of small quantities of dusting powder such as french chalk or zinc stearate. This treatment reduces the coagulum to a coarse crumb which can be converted into a more finely divided product by passing it still wet through a mechanical disintegrator, which consists of rapidly revolving bars which force the crumb through a sieve of the required mesh.

In order to disintegrate the wet coagulum it is desirable to render it as friable as possible and a number of methods are available. If latex is treated with powdered stearic acid before coagulation or with compounds of fatty acids, it is found that the wet coagulum is more easily disintegrated. The friable nature of the coagulum can also be increased by soaking it in water or in dilute alkali such as ammonia or caustic soda. As a general rule the greater the absorption of water by the coagulum the easier it is to disintegrate. If the latex is mixed with suitable mineral compounding ingredients and then coagulated the friable nature of the coagulum is increased, or the wet coagulum may be machined with large quantities of mineral compounding ingredients.

A particularly interesting method of increasing the friable nature of the coagulum is to treat the latex with a small quantity of sodium nitrite, which quickly reacts with acetic or formic acid to yield a compound which has a chemical action upon caoutchouc. The coagulum is easily disintegrated and the dry product is a modified rubber crumb with useful properties.

The quality of the crumb obtained by any of these methods of mechanical disintegration naturally depends upon the particular variant of the process employed. In no case is it possible to obtain the same degree of sub-division as by spraying latex but the particles are sufficiently fine for some purposes and do not contain large quantities of protective colloids which may be detrimental to the use of powder prepared by spraying.

There is still another type of process for preparing rubber in crumb form, chiefly of interest to manufacturers. This consists in compounding latex with large quantities of powders in the presence of small quantities of protective colloids. On the addition of further quantities of powder a soft crumb-like

coagulum is formed (B.P. 327,451, 1929) in which the powders are evenly dispersed. By this method it is possible to incorporate larger quantities of powder with rubber than by the customary method of mixing them with crepe or sheet on mixing rolls.

It is not possible at this stage to make reliable comments on the commercial prospects of the different processes. Little information is available as to the cost of production and it is obvious that they are not all suitable for the same purpose. The various types of powders have been produced experimentally only and applications suggest themselves which are not available to crepe and sheet. These applications are still under investigation.

RUBBER ROADWAYS*

THE use of rubber for paving the streets was discussed on 19th October at a meeting of the Common Council in the City of London. The Lord Mayor was in the chair. Mr. A. Galloway asked for information about the rubber paving at the end of New Bridge Street. Though, he said, that paving was laid down four years ago there had been no report on it. The Rubber Exchange, which was in his Ward, was intensely interested in the experiment. Mr. Gower, Chairman of the Street Committee, replied that every member of the Committee was most anxious to have rubber roadways as soon as a suitable material could be found. Ten or 12 days ago he went, with the engineer, to view the section of New Bridge Street paved with rubber. They came away feeling that there was still a long way to go. There was also the economic point of view. The cost of rubber roadways was about four times as much as that of wood or asphalt. Though he would be quite willing to bring forward a proposition to pay the increased cost, the Committee must be quite sure that they had the right article.

PIONEER COMPANY'S LETTER

In *The Times* of 9th November appeared the following letter to the Editor:—

> SIR,—Under the headings: "Rubber Paving in the City: the New Bridge Street Experiment," you published on 20th October an account of a discussion at a meeting of the Common Council in the City, in which Mr. Gower is reported to have said in reference to a visit to New Bridge Street, "that there was still a long way to go."
>
> There are three rubber sections in New Bridge Street. They are:—(1) The original cream-coloured "Gaisman" block laid in October, 1926; (2) the improved black "Gaisman" block laid in October, 1932, south of the original section and adjacent to it (*i.e.*, nearer Blackfriars Bridge); (3) a ribbed grey rubber block, laid in March, 1933, a few yards north of the above two sections (*i.e.*, nearer Ludgate Circus). Sections 1 and 2 were laid by my firm. Section 3 was laid by another firm, and we have no connection with their block or their experiment.

* From the *India-Rubber Journal*, November 18, 1933.

As we claim that section 2 is, after a year's intensive test, thoroughly and completely satisfactory, it would be interesting to know in what respect Mr. Gower, if he has seen that particular section, can say "that there is still a long way to go."

Yours faithfully,

L. GAISMAN.

Managing Director,
Universal Rubber Paviors, Ltd.,
Audenshaw, near Manchester.

RUBBER ROAD BLOCKS

During the past two years developments of some importance have taken place not only in the application of rubber as a road surfacing material, but in the use of rubber for such purposes as traffic lines, pavement kerbs, and traffic signal posts.

Dealing first with the rubber block, which for a period of years has satisfactorily withstood the test of the most intensive traffic conditions, an area of 1,200 square yards of the "Gaisman" Improved Block was laid in August, 1932, in Market Street, Huddersfield. This improved block is of the same construction as the block laid in New Bridge Street, London, in October, 1926, but is smaller in size. An important alteration, however, has been made in the quality of the tread. A good deal of experience has been gained in New Bridge Street in the seven years that have passed since the date of laying of the old type of block in 1926. During this period the blocks have carried an exceptionally heavy traffic, estimated at 48,500 tons per day, which with week-end and night traffic brings the weight to about 300,000 tons per week, or a total of 109,200,000 tons for seven years. The blocks have withstood this great test, but in course of time it became evident to the makers that the quality of the tread to withstand the strain of heavy traffic must be such as to resist tear as well as attrition. The quality of the tread in the improved block has been so altered that it is three times stronger in this respect than the tread in the old block.

THE MERSEY TUNNEL

Perhaps one of the most important demonstrations of the rubber block is the new type "Gaisman" shallow block cast on an iron base, of which an area of 2,000 square yards will be laid shortly in the Mersey Tunnel. This demonstration is of particular interest, because it is a known fact, from experience gained

in similar tunnels in America, that the noise of vehicular traffic in a long tunnel is almost unbearable, and it is of great importance to engineers and to the Rubber Industry to demonstrate the extent to which this noise can be reduced by a rubber roadway. The question of absorption of vibration is equally important.

Including the Mersey Tunnel area there will now be over a dozen demonstration areas of rubber road blocks involving a total area of 7,500 square yards. Rubber roadways are in existence at Glasgow, Edinburgh, Newcastle-on-Tyne, Bristol and Rotterdam; special blocks for pedestrian and light traffic are to be seen on the Hastings promenade. The use of rubber flooring for stables and cowsheds is rapidly extending.

TRAFFIC LINES AND KERBS

Until recently little attention has been given to the possibilities of rubber as a permanent material for marking traffic lines. A few years ago trials were made of several types of white line blocks, and we understand the North British Rubber Company is now specializing in this direction. The desire for a yellow coloured line has revived interest in rubber as a suitable material, and it is of interest to note that in the Mersey Tunnel all the traffic lines will be composed of "Gaisman" yellow rubber blocks.

Another product incorporating rubber, which possesses great potentialities, is the rubber-concrete kerb, a new type having been put on the market by Universal Rubber Paviors, Ltd., of Audenshaw, Manchester, the manufacturers of the "Gaisman" road blocks and traffic lines. The rubber kerb can be supplied recessed to permit of stone paving being used, or alternatively a rubber pavement block similar to the "Gaisman" pavement blocks laid at the promenade, Hastings. The rubber-concrete kerb has been laid along the new East Lancashire Road, and similar kerbs will be laid around the Plazas at the Birkenhead and Liverpool entrances to the Mersey Tunnel.

BOLLARDS AND TRAFFIC POSTS

The utilization of rubber-covered bollards and traffic posts would present great advantages if they were produced in suitable colours at a reasonable price. Such types would be visible and require no upkeep, as the colours would be permanent; further, the cushion provided by the rubber would lessen the danger in the case of accidents to persons or vehicles. Types of rubber-covered bollards and traffic posts have now been produced by

Universal Rubber Paviors, Ltd., and were shows at this week's Rubber Works Exhibition at the Royal Agricultural Hall, London.

RUBBER CEMENT AND BITUMINOUS MIXTURES

The pioneer work in connection with rubber road blocks has extended over a long period of years. During that time attention has been directed to the production of what might be termed the "lower order" of rubber roads, the object being the provision of less costly material, which although not comparable in quality or service with the vulcanized rubber block, would be suitable for secondary streets and county roads, and compete with such materials as asphalt. The question may be asked why progress in this direction has been so slow. An examination of the patent literature will show that inventive genius has not been lacking. During the past ten years over 130 patents have been taken out dealing with rubber and latex in road construction materials (excluding blocks). The problem, however, is not a simple one. The principal technical problem in early experimental work with rubber as a road surface material was to find a satisfactory method of attaching the rubber compound to the rigid foundation so that once laid there would be no "creeping" or shifting of the material, and further that the surface would be such that water could not percolate to the foundation. For these reasons investigations have been developed on the lines of rubber compounded blocks anchored to a rigid base, and it was found that in their manufacture a high quality compound must be used and the material vulcanized under pressure.

Interest in the rubber carpet idea has been revived owing to rapid progress in the production and marketing of liquid latex, due to the increasing demand for rubber in this form in new rubber manufacturing processes.

Some years ago small tests were made in Ceylon and the Netherlands Indies with emulsions of latex and bitumen. Later, small-scale trials were made with a mixture of concentrated latex, cement, and other fillers which could be applied to the road surface in plastic form. An area of this type of material was laid about a year ago at the entrance to the new Goods Yard, Bishop's Road, Paddington.

MALAYAN RESEARCH

Since 1931 the Rubber Research Institute of Malaya has been carrying out an investigation into roadway preparations

incorporating latex. According to the Institute's last annual report published in August, 1933, trials have been made of various materials. It is stated that the result of the work carried out confirms the opinion that the production of a really satisfactory roadway material direct from latex is still a matter of difficulty. Promising non-cracking preparations have been produced with cement and creamed latex. A stage has been reached at which little more can be done until the practical trial of some of these preparations indicates their possibilities under service conditions. This involves other lines of work concerned with the mixing apparatus, which are in hand.

The Rubber Growers' Association, under the auspices of its Technical Research and Development of New Uses Committee, has initiated an investigation into the incorporation of latex with highway surface construction materials. The work is being carried out under the supervision of Professor R. G. H. Clements, at the Imperial College of Science (City and Guilds Engineering Institute), and an extensive programme of research has been planned.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the eighteenth meeting of the Board of Management, held at 11 a.m. on Thursday, September 21, 1933, in Room No. 202, New Secretariat, Colombo.

Present.—Dr. W. Youngman (in the chair), Messrs. C. W. Bickmore, C.C.S., (Deputy Financial Secretary), I. L. Cameron, A. E. de Silva, H. R. Freeman, M.S.C., L. P. Gapp, F. H. Griffith, Col. T. G. Jayewardene, V.D., Messrs. J. L. Kotalawala, M.S.C., F. A. Obeyesekere, M.S.C., C. A. Pereira, B. M. Selwyn and E. W. Whitelaw.

Mr. T. E. H. O'Brien, Director of Research, was present by invitation and acted as Secretary.

Letters of apology for absence were received from Mr. E. C. Villiers, M.S.C., and Mr. B. F. de Silva.

Dr. Youngman reported that he returned from leave on August 6, 1933, and resumed the Chairmanship of the Board from that date.

MINUTES OF THE 17TH MEETING OF THE BOARD

Draft minutes which had been circulated to members were confirmed and signed by the Chairman.

The Chairman said that, before starting the business on the agenda, he would like to report that he had met the London Advisory Committee for Rubber Research (Ceylon and Malaya) while on leave and visited the Committee's laboratories at the Imperial Institute. We were much indebted to the Imperial Institute for the free use of the laboratories. He had found a feeling of great good-will and a desire to do everything possible to co-operate with the Board. He was very favourably impressed with the work of the staff, especially their trials in connection with the preparation of cheap rubber flooring (samples shown). He had also visited a factory at Kew for the treatment of coir and other fibres. It seemed from what he saw there that a satisfactory floor covering might be possible of manufacture from treated coir dust and rubber latex. He hoped that the patentee would be able to institute manufacture locally. He had seen new uses of rubber on farm vehicles at Rothamsted, and elsewhere, but the cost of the equipment was high. He was impressed with the possibilities of rubber paving blocks for pig-pens, cow-sheds and other flooring, but there was some difficulty about making satisfactory joints, which he hoped could be overcome. He had attended a meeting of the London Advisory Committee and the Technical Sub-Committee. It was a Committee of very eminent scientific and business men who were solely interested in the good of the rubber industry. We were greatly indebted to them for the

time they gave in order to help us. He had taken the opportunity of correcting certain impressions which he thought might exist. They would welcome visits from Members of the Ceylon Board when in London. They too would be glad to arrange a period of training at their laboratories at the Imperial Institute for an Assistant Chemist either in the case of a man recruited locally or abroad. He had been much impressed with the scientific discussion at the Technical Committee meeting.

BOARD

(a) The Chairman reported the renomination of the following members for a period of 3 years from the expiry of their present term of office:

Messrs. C. E. A. Dias, J.P., & A. E. de Silva, November 16, 1933.

Mr. F. H. Griffith, November 16, 1933,

Col. T. Y. Wright, November 16, 1933,

Mr. C. A. Pereira, November 16, 1933,

Mr. B. F. de Silva, November 24, 1933,

(b) The Chairman reported a resolution which had been adopted by the Ceylon Estates Proprietary Association in favour of the alteration of the Rubber Research Ordinance to provide for the appointment of an unofficial Chairman.

In reply to an enquiry whether there was any recent information regarding the affairs of the Rubber Research Institute of Malaya the Chairman referred to a résumé of the findings of the Commission of Enquiry published in the "Times of Ceylon" of September 19th. He said that the difficulty of Chairmanship had apparently been overcome there by a recommendation that the Director of the Institute should be Chairman.

ACCOUNTS

(a) Statement of receipts and payments of the London Advisory Committee for the quarter ended June 30, 1933, was adopted without discussion.

(b) Experiment Station Accounts for July 1933 were tabled.

(c) *Employees' Provident Fund.*—The Chairman reported that the rules of the Fund adopted by the Board on February 16, 1933, had been approved by His Excellency the Governor in Council and the Hon'ble the Minister for Agriculture & Lands was taking steps to lay them on the table of the State Council and had enquired if the Board would bear the cost of prior publication in the *Gazette*. This was approved.

STAFF

The Chairman reported that a large number of applications had already been received for the post of Assistant Chemist. He proposed the appointment of a small Committee to consider the applications and recommend say half a dozen names to the Board. A full list of applicants and their qualifications would be submitted to Board members. A Committee consisting of the Chairman, Mr. F. A. Obeyesekere and Mr. B. M. Selwyn was appointed to consider the applications in consultation with the Director of Research.

DEVELOPMENT OF THE RESEARCH SCHEME

(a) The Chairman reported a resolution which had been adopted by the Committee of the Low-country Products Association in connection with the purchase of Dartonfield Estate. The Board generally expressed great disappointment at, and disapproval of, certain statements made in this connection. It was, however, decided to leave the matter alone unless the controversy was continued.

(b) After discussion, the following permanent Committee was appointed to deal, in consultation with the Director, with matters relating to the working of the experimental estate: Mr. F. H. Griffith, Col. T. G. Jayewardene, Mr. J. L. Kotalawala and Mr. E. W. Whitelaw. The Committee will elect its own Chairman who will have a casting vote. It was decided to continue the present arrangements for the management of the estate until January 1, 1934, and to appoint a full time Superintendent from that date. The Committee was authorized to take the necessary steps to select a suitable officer.

(c) The Estate Committee was asked to make an early recommendation regarding the acquisition of Crown land.

LONDON ADVISORY COMMITTEE

Minutes of meetings of the Advisory Committee and of the Technical Sub-Committee held on June 23, 1933, were adopted.

TECHNICAL REPORTS

(a) Technical officers' reports for May, June and July, 1933, were adopted.

(b) The following reports were tabled:

"Double Cut" Tapping Systems in Ceylon—R. K. S. Murray.
Report on Softened Rubber—London Advisory Committee.

PUBLICATIONS

The following publications were tabled:

Eleventh Annual Report of the Rubber Research Scheme,

Second Quarterly Circular for 1933.

RUBBER-GROWERS' ASSOCIATION

The Chairman referred to a letter from the Secretary, Rubber Growers' Association and enquired whether members wished to receive copies of reports of the Technical Research and Development of New Uses Committee. It was decided to ask each member whether copies of future reports are required.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the nineteenth meeting of the Board of Management, held at 11 a.m. on Thursday, November 23, 1933, in Room No. 202, New Secretariat, Colombo.

Present.—Dr. W. Youngman (in the chair), Messrs. C. W. Bickmore, C.C.S., (Deputy Financial Secretary), I. L. Cameron, B. F. de Silva, C. E. A. Dias, J.P., H. R. Freeman, M.S.C., L. P. Gapp, F. H. Griffith, Col. T. G. Jayewardene, V.D., M.S.C., Messrs. J. L. Kotalawala, M.S.C., F. A. Obeyesekere, M.S.C.. C. A. Pereira, E. C, Villiers, M.S.C., E. W. Whitelaw and Col. T. Y. Wright.

Mr. T. E. H. O'Brien, Director of Research, was present by invitation, and acted as Secretary.

Apology for absence was received from Mr. B. M. Selwyn.

1. MINUTES OF THE EIGHTEENTH MEETING OF THE BOARD

Draft minutes which had been circulated to members were confirmed and signed by the Chairman.

2. BOARD

The Chairman reported the resumption of membership by Col. T. Y. Wright on his return to Ceylon.

3. DEVELOPMENT OF THE RESEARCH SCHEME

(a) Minutes of meetings of the Estate Committee held on October 23 and November 6, 1933, were considered under the following headings :—

Crown land for experiments.—In connection with the Committee's recommendation to apply for 100 acres of Crown land at Pinnagoda for experimental purposes the Chairman reported that it would be necessary to submit a detailed statement of the use to which the land would be put, before the matter could be considered by the Executive Committee for Agriculture and Lands. It was decided that a statement should be prepared.

Estimate for Dartonfield Estate 1933.—An estimate of expenditure for the period August-December, 1933, amounting to Rs. 5,312 was approved.

Estate Superintendent.—The Committee was authorized to proceed with the appointment of an Estate Superintendent on the terms advertised.

Experimental Factory.—The proposal to erect an experimental factory at Dartonfield was approved and the Committee was authorized to call for plans and estimates from local engineering firms.

(b) *Research on the utilisation of raw rubber.*—The policy of the Research Scheme in relation to research on the utilisation of raw rubber was discussed in connection with a letter from the Hon'ble the Minister for Agriculture and Lands, drawing attention to the inadequacy of the results achieved in this direction up to the present. The Director of Research was instructed to prepare a memorandum giving particulars of progress in this branch of work to date and submitting proposals for future work.

4. ACCOUNTS

(a) *Estimates of Income and Expenditure for 1934.*—Draft estimates of income and expenditure for 1934 were considered. After full discussion, during which it was decided to make provision for the appointment of a Secretary and to consider staff salary scales at a future meeting, the following estimates were adopted :—

Income	... ...	...	Rs. 147,830
Expenditure	Recurrent	Rs. 114,962	
,,	Non-recurrent	,, 78,300	,, 193,262

(b) Statements of receipts and payments of the Board and of the London Advisory Committee for the quarter ended September 30, 1933, were adopted.

(c) Experiment Station accounts for September and October, 1933, and Dartonfield Estate accounts for August, September and October, 1933, were tabled.

5. APPOINTMENT OF AN ASSISTANT CHEMIST

The Chairman reported that 79 applications for the appointment had been received and had been considered by the Selection Committee. The Committee recommended 3 candidates in order of preference. The choice was approved by the Board and the Chairman was authorized to offer the appointment to the first candidate by cable, subject to a satisfactory medical certificate being submitted. It was decided that the officer should be asked to spend 2 weeks at the laboratories of the London Advisory Committee before proceeding to Ceylon.

6. TECHNICAL REPORTS

The following reports were tabled, prior to publication :—

"Method of Preparing Raw Rubber in Crumb and Powder Form". —G. Martin.

"The Preparation of Soft Rubber with Sodium Nitrite".—G. Martin

"Notes on Low Temperature Vulcanization.—T. E. H. O'Brien.

Research Scheme Laboratories,
Culloden, Neboda.
5th December, 1933.

RUBBER RESEARCH SCHEME (CEYLON)

LIST OF PUBLICATIONS FOR SALE.

Bulletins Re. 1-20. Bound volume **Rs. 5-00. Later Bulletins Re. 1-00** per copy

No. 1. The Effect of Tapping on the Movements of Plant-Food in Hevea brasiliensis.
No. 2. The Effect of Tapping on the Movements of Plant-Food in Hevea brasiliensis.
No. 3. Seasonal Variations in the Movements of Plant-Food in Hevea brasiliensis Part I.
No. 4. The Physiological Effects of Various Tapping Systems, Part I.
No. 5. Progress Report on Vulcanization Tests
No. 6. The Physiological Effects of Various Tapping Systems, Part II.
No. 7. Do Do Do Part III
No. 8. Seasonal Variations in the Movements of Plant-Food in Hevea brasiliensis, Part II.
No. 9. Vulcanization Tests.
No. 10. Do.
No. 11. Variability in Rubber Manufacture.
No. 12. Progress Report of the Rubber Research Chemist.
No. 13. Vulcanization Tests.
No. 14. On the Variation in the Number of Latex Vessels present in Hevea brasiliensis.
No. 15. Vulcanization Tests.
No. 16. On the Natural Clotting of Rubber Latex.
No. 17. Vulcanization Tests.
No. 18. Measurements of "Bark Renewal."
No. 19. Vulcanization Tests.
No. 20. Do.
No. 21. Do.
No. 22. Do.
No. 23. Do.
No. 24. Do.
No. 25. Investigations on Samples of Plantation Para Rubber from Ceylon.
No. 26. Results of Trials of Ceylon Plantation Rubber for the manufacture of Ebonits.
No. 27. Investigations on Samples of Plantation Para Rubber from Ceylon.
No. 28. Do.
No. 29. Summary of the Principal Results obtained from Investigations into the Properties of Ceylon Plantation Rubber in relation to its Method of Preparation.
No. 30. The penetration of disinfectant on the tapping cut of Hevea brasiliensis.
No. 31. On the Occurrence of "Rust" on Sheet Rubber.
No. 32. On the Preservation of Latex.
No. 33. Investigations on Samples of Plantation Para Rubber from Ceylon.
No. 34. Do.
No. 35. Do.
No. 36. Do.
No. 37. Do.
No. 38. Do.
No. 39. Do. (Final Report Series I.)
No. 40. Do Series II.
No. 41. Do. First Interim Report on artificial ageing tests.
No. 42. On the Smoking of Sheet Rubber in relation to Mould Prevention.
No. 43. The inter-relationship of Yield and the various Vegetative Characters in Hevea brasiliensis. (out of print).
No. 44. The Construction of Smokehouses for Small Rubber Estates. (out of date).
No. 45. The Efficiency of Disinfectants and Fungicides.
No. 46. The Control of Bark Rot by Disinfectants.
No. 47. Report on Variability of Ceylon Estate Grades.
No. 48. Brown Bast and its Treatment.
No. 49. Report on Causes of Variation in Plasticity.
No. 50. Crepe Rolling.
No. 51. The Curing of Sheet Rubber.
No. 52. The Preparation of Uniform Rubber.

Booklets at Rs. 2-50 per copy.

Guide to the Preparation of Plantation Rubber, by T. E. H. O'Brien, M.Sc., A.I.C., Chemist.
The Budding of Rubber, by R. A. Taylor, B.Sc., Physiological Botanist.
Diseases of Rubber in Ceylon, by R. K. S. Murray, A.R.C.Sc., Mycologist.